Molecular Evolution, EEOB 566

Course overview

What a great time this is to be a biologist! Nowhere is this more evident than in evolutionary genomics, where are now able to study genomes with astonishing precision and depth. Because of this, my inbox is filled daily with all kinds of wonderful new discoveries about life, about genomes, about the *molecular evolution* of organisms, and about how all of the above is shaped by drift and selection.

In EEOB 566 we will explore this world. And it will be an adventure, I promise.

What will we actually do? Well, 566 is a seminar/discussion course covering the fundamentals of gene and genome evolution as well as a variety of advanced topics in the field. The overall objective is to develop an understanding of modes and mechanisms of gene and genome evolution, *and to be able to express this understanding in conversation*. Using almost exclusively current literature, we survey the field and consider many different topics in depth, ranging from mutation at the nucleotide level to sudden changes in entire genomes. We will emphasize the present state of the field. Everyone in in the class also will gain experience in synthesizing the literature on a specific topic in molecular/genome evolution, and will have the opportunity to share this synthesis in the form of a mini-lecture and review paper.

Recommended (only a little bit; not required) textbook

Molecular and Genome Evolution, by Dan Graur, 2016 (Sinauer Press). If cash isn't a problem (😉)… the book is useful, but doesn't parallel the course material.

Learning outcomes

This course will enable you to understand the fundamental processes that shape gene and genome evolution in eukaryotes. After the course, my hope is that you will be able to describe:

- patterns and processes that shape mutations, genic evolution, protein evolution, and non-coding sequences;
- the primary forces and mechanisms that are responsible for genome size evolution;
- the molecular clock and why there exists rate variation;
- the centrality of transposable elements to genome evolution;
- the diversity of organellar genomes;
- the nature of horizontal transfer of DNA through non-sexual (horizontal) means;
- and other topics too numerous to mention.

You also will be able to visualize the numerous connections between molecular evolutionary processes and biological phenomena at other scales of organization, from the cellular to the ecological. Remember, ***no evolution takes place outside of an ecological context.***

Course content and approach

We will meet twice weekly for 80 minutes, from **9:30-10:50 Tuesdays and Thursdays** in room 334, but most often by Zoom. This course really benefits from remote meetings, in that everyone can pull papers up on their own computer and can share screens easily, and also because we can

quickly form breakout rooms for mini-discussions. ***Each class period will include a discussion of relevant literature that we all will read for that class period***.

Please do your best to **be prepared for each class and for our discussion**, and please also contribute to our collective conversation on a daily basis, even if only through questions about ideas that you find confusing. Questions are the most important part of our conversations! Remember, our goals are to enhance our individual and collective understanding of sometimes complicated concepts or methods or results, to probe and share our thinking about implications, and to enhance our ability to express this understanding in a supportive environment. This latter element, expressing yourself, will be important to your professional success irrespective of your chosen field, in academia or government or private industry.

The course format changes in the final 2 weeks, when we transition from paper discussion to focused, student-selected presentations (see Individual Projects, see below).

Iowa State University supports and upholds the First Amendment protection of freedom of speech and the principle of academic freedom in order to foster a learning environment where open inquiry and the vigorous debate of a diversity of ideas are encouraged. Students will not be penalized for the content or viewpoints of their speech as long as student expression in a class context is germane to the subject matter of the class and conveyed in an appropriate manner.

MOLECULAR EVOLUTION (EEOB 566), FALL, 2024			
DATE (T)	**TOPIC**	**DATE (TH)**	**TOPIC**
Aug. 27	Introduction	Aug. 29	The genetic code, mutation
Sept. 3	Sequence evolution	Sep. 5	Rate variation, molecular clocks
Sept. 10	Sequence diversity I: how much and where	Sept. 12	Sequence diversity II: evolutionary forces
Sept. 17	Coalescence, lineage sorting, gene vs. species trees	Sept. 19	Adaptive molecular evolution I
Sept. 24	Adaptive molecular evolution II	Sept. 26	Adaptive molecular evolution III
Oct. 1	Gene duplication I: mechanisms, theory	Oct. 3	Gene duplication II: examples, copy number variation
Oct. 8	Gene conversion, "concerted evolution"	Oct. 10	Genome duplication I: short-term consequences
Oct. 15	Genome duplication II: long-term consequences	Oct. 17	Transposable elements I
Oct. 22	Transposable elements II	Oct. 26	Transposable elements III
Oct. 29	Comparative genomics I: within species	Oct. 31	Comparative genomics II: among species
Nov. 5	Comparative genomics III: genome size evolution	Nov. 7	Mitochondrial genomes
Nov. 12	Plastid genomes	Nov. 14	Intergenomic DNA transfer within species
Nov. 19	Horizontal transfer between species	Nov. 21	Work on talks and papers
Dec. 3	Student presentations	Dec. 5	Student presentations
Dec. 10	Student presentations (if needed)	Dec. 12	Student presentations (if needed)

- *This is largely a discussion class, where we meet to discuss and synthesize current literature in molecular evolution, in the context of broader issues in the field. We meet on Tuesdays and Thursdays from 9:30-10:50.*
- *There are no tests. Course grades will be determined by participation (2/3; including discussion summaries) and by individual projects (1/3). All papers and other pertinent course materials will be posted in our shared folder.*
- *There will be a few class periods that are run by class participants, with everyone writing their personal synopsis of what was learned.*

Individual Projects Molecular Evolution (566)

Individual Purpose

1. To develop an in-depth understanding of an issue in molecular evolution that we will not have time to cover together as a class.
2. To gain experience in delivering a teaching lecture by presenting to the class what you have learned (lucidly and effectively).

Collective Purpose

1. To broaden our exposure to issues that we will not formally cover during the course.
2. To appreciate the diversity of approaches that legitimately may be used in lecture style and organization.

Procedure

1. Select a topic of interest. You might feel more comfortable delaying this decision until you have a clearer sense of the scope of the field and of the class. The topic should be ***broad enough*** to be of interest to a wide variety of readers/listeners. As an example, the evolution of intron sequences in the cpDNA gene *rpl16* in the bamboo genus *Chusquea* is not an appropriate focus, but the evolution of non-coding DNA is. See the difference? When you have some notion of what topic or topics might interest you, please see me so we can discuss your choices. ***Please do this by October 1 (calendar alert*)***.
2. Study the relevant literature, paying particular attention to ***central issues and ideas***, although applications and examples may also be important.
3. Write a paper, which should be thought of as a ***mini-review***, as if you are targeting one of *Trends* or *Current Opinions* journals. There is no required format except the rather obvious one that it be well-written and thorough in coverage and documentation. Lengths are expected to vary according to topic, but there is a limit of 2000 words, excluding citations and figure legends. Figures and tables are limited to 4 in number. ***Papers are due by 5:00 p.m. on December 10th (calendar alert*)***, but are welcome prior to this time. If you wish for me to view an early draft, I will happily comment on content and organization, but not wording or clarity of expression.
4. The final two weeks of the semester will consist of formal presentations by each class member (order to be determined later). You should plan on giving a 20-minute powerpoint lecture. The goal is to impart in the rest of us an understanding of your topic. Feel free to electronically distribute handouts if they will assist in understanding your lecture (*but no required reading*). Similarly, you might include literature lists for everyone's files (*again, no assigned reading*!). ***Powerpoints will be shared in our class Cybox folder, so that everyone can review and learn from your work***. ***Name your presentation using the convention "your name, title of talk, date".***